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THE EDITOR'S OFFICE

Ten Times a Year. With this issue (the sixth one), THE COMPUTING MACHINERY FIELD changes its name to COMPUTERS AND AUTOMATION, and will be published monthly ten times a year, omitting June and August. For discussion of the word "automation", see the article in this issue "The Concept of Automation".

The basic subscription rate will remain at $3.50 a year until March 31, and on April 1 will change to $4.50 a year. Existing subscriptions will run without change to the date they were previously scheduled to expire, as an expression of our appreciation to our early subscribers.

More Articles. We have begun to publish longer articles, up to about 4000 words. We hope to cover the whole field of computing machinery, automatic control, cybernetics, robots, automatic materials handling, and related subjects.

Some of the articles planned for future issues are one by Willy Ley, author of "The Conquest of Space", on automatic controls in rockets and spaceships; one by James Gibbons on the application of automatic data-processing machinery in a worsted mill; and one by Fletcher Pratt, author of "Secret and Urgent", on the solving of ciphers with automatic machinery.

More Reference Information. In addition to the "Roster of Organizations Making or Developing Computing Machinery", and the "Who's Who", we have begun to publish in this issue a "List of Automatic Computers" and the start of a "Glossary".

Back Copies. For information about back copies, see the note on page 16.

Manuscripts. For information about manuscripts wanted and rates, see the note on page 8.

NOTICE

COMPUTERS AND AUTOMATION, beginning March 1, 1953, is published ten times a year, monthly except June and August, by Edmund C. Berkeley and Associates, 36 West 11 St., New York 11, N.Y.

Subscription rates until March 31, $3.50 for one year, $6.50 for two years, in the United States and Canada; $4.50 for one year, $8.50 for two years, elsewhere. Subscription rates effective April 1, $4.50 for one year, $8.50 for two years, in the United States and Canada; $5.50 for one year, $10.50 for two years elsewhere.

Application for entry as second class matter is pending.

If your address changes, please notify us giving both old and new addresses, and allow three weeks for the change.

Vol. 2, No. 2 March, 1953

ARTICLES

REFERENCE INFORMATION

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GYPSY, MODEL VI, CLAUDE SHANNON, NIMWIT, AND THE MOUSE

by George A. W. Boehm
Science Editor, Newsweek

Two of the hardest working computers in the country are stationed at the Bell Telephone Laboratories in Murray Hill, N.J. One is a differential analyzer, known familiarly to the Bell Labs staff as Gypsy, a corruption of GPC (general purpose computer). At the heart of its calculating system, amplifiers and condensers simulate and enact physical problems. The other machine, the Model VI, takes the digital approach, with 4,600 electric relays performing such numerical tasks as adding, subtracting, multiplying, and dividing.

A particularly interesting job recently assigned to the analyzer was to calculate the path of a coin inserted in a pay telephone. This question bears directly on one of the telephone companies' most persistent and annoying problems: how to foil the petty crook who feeds slugs into the slot. Partway down it bounces. Thus, mathematically, its motion is discontinuous and is best represented by two distinctly different equations. One describes the initial plummet. The second applies to the flip and tumble which the coin takes after it bounces.

As digital computers go, Model VI is not exceptionally fast; yet it takes only 0.8 seconds to multiply two five-digit numbers. It is quite rapid enough to handle the work which Bell Labs engineers assign it. Most important, its reliable relays make it one of the steadiest workers in the computing machinery world. Since it began fulltime operation three years ago, Model VI's steady habits have improved gradually until last November, its time sheets reveal, it averaged more than 24 hours of work per day. This implausible record is, in part, a statistical figment. For purposes of this calculation, "day" was defined as "regular working day." And the computer inflated its average by laboring unattended on many weekends and holidays. It has recently done its part in designing electronic filters to disentangle the messages that will be sent over the Bell System's new L-3 coaxial cable. This cable is now being installed between New York and Philadelphia and will be able to transmit simultaneously more than 1,800 telephone messages. Alternatively, one television program, in either direction, can be substituted for 600 telephone conversations.

While these two computers drudge tirelessly, a growing flock of smaller machines play parlor games at Bell Labs. Boss and chief designer of this seemingly frivolous group is Dr. Claude E. Shannon, a 37-year-old mathematician notable for his work on thinking machines of various types.

Shannon's interest in machines that play games started as a hobby. One of his earliest successes was a homemade cart which dashed to and fro to balance a stick on end. The stick was pivoted at its base so that it could topple backwards and forwards but not to either side. In a more personal approach to the problem of balancing, Shannon has mastered the knack of bounding along on a pogo stick and is now learning to ride a unicycle.

Bell Labs has been glad for Shannon to convert his pasttime into a long-range development project in working hours at Murray Hill. The switching system in a telephone office is in a sense an elaborate game-playing machine. Its electric

relays must connect or disconnect telephone users as rapidly and as efficiently as possible. And any slight improvement in the speed or accuracy of this switching system is reflected in better service at lower cost. Shannon's machines, most of which rely on relay mechanisms identical in principle with those of a telephone switching system, are proving grounds for new ideas in telephony.

The simplest of his game-playing machines solves the ancient puzzle known as the Tower of Hanoi. This game starts with three posts. On one are stacked several disks of graduated size — the largest at the bottom, the smallest at the top. The problem is to transfer the stack to another post, without moving more than one disk at a time and without ever putting a larger disk on top of a smaller one.

Shannon's machine has 14 relays which follow a set line of play and, using six disks, solve the puzzle in 63 moves. This is the minimum number of moves for six disks. An Indian legend relates that beneath the great temple at Benares, which marks the center of the world, rests a brass plate skewered by three diamond needles each a cubit tall and as thick as the body of a bee. On one of these needles, God placed 64 disks of pure gold. Day and night, priests transfer the disks according to the laws of Brahma, which in this case are identical with the rules of the Tower of Hanoi puzzle. When the priests have finished their job, the world will come to a cataclysmic end. Whereas Shannon's machine solves the six-disk puzzle in less than two minutes, the Brahman priests will have to hurry to finish their task in less than 60 billion years.

Another of Shannon's machines simulates the Chinese Ring puzzle, which consists of removing a number of rings from a bar. These rings are so joined by chains that any rings can be slipped off only when the one next to it toward the end of the bar is <u>on</u> and all beyond that one are <u>off</u>. In his version Shannon has substituted lights that can be switched on and off in accordance with the conventional rules.

The Tower of Hanoi and the Chinese Ring puzzle are in the modern sense rudimentary thinking machines. They follow a logical and prdetermined pattern of play without referring to the moves which they have already made. Shannon's other machines represent higher levels of sophistication.

One is the Nimwit, which plays expertly at Nim. This game has several versions. Perhaps the most common starts with a pile of matches. The first player may remove one, two, or three matches. Then the second player may remove one, two, or three matches. The two contestants take turns until the pile is exhausted. each trying to force his opponent to remove the last match.

Shannon's version, played by his machine against a human opponent, consists of three rows of lights, with a maximum of seven in each row. The moves are made by turning off any number of lights in one row. The machine can be preset to play any of three sub-versions. It can attempt to leave the last light for its opponent. Or it can attempt to extinguish the last light. Or it can play under the restriction that not more than three lights may be turned off in any row in one move. No matter which set of rules, the Nimwit always wins if given the first turn and a favorable starting position. By moving first, an opponent can win in most cases, but when losing the Nimwit plays to prolong the game as far as possible. Its brain is built around a thinking network of 45 relays.

Still more complex is a machine that plays Hex, a board game invented at Princeton University. The board is a rhombus packed in a beehive fashion with hexagonal spaces. The players take turns occupying empty spaces with counters, the object

being to construct an uninterrupted string of counters from one edge of the board to the opposite edge. Unlike tic-tac-toe, chess, or checkers, Hex can never end in a tie.

Shannon's Hex machine uses colored lights instead of counters. The human opponent presses a plunger to illuminate a red lamp beneath any hexagon he chooses to occupy. Then, after a delay of several seconds, the machine turns on a yellow lamp under the hexagon of its choice. Shining diffusely through the board of milky plastic, the colored lights make Hex the showiest of Shannon's games. For the human opponent it is also the most frustrating. Shannon has cheated in favor of his machine. On close inspection, the board turns out to be a parallelogram. The machine advances its chain of lights toward an edge only seven hexagons away, whereas its opponent's shortest line of play is eight hexagons long. This handicap, plus the simple strategy of matching its opponent's every move by filling a corresponding space, gives the machine an insurmountable advantage. Nominally, the machine's hesitation in moving is occasioned by thinking. Actually, its relays snap closed almost instantaneously; the delay is caused by thermistors which take a couple of seconds to heat up and pass current to the yellow lamps. This stratagem of design adds to the aura of mystery and to the outmatched opponent's frustration.

All the aforementioned machines compute their plays with mathematical precision. In still another machine Shannon has devised an electrically intuitive approach. It plays Bird Cage, a game of Shannon's own invention. The board is a square of 36 spaces, the object, as in Hex, being to fill a string of spaces from one edge of the board to the opposite edge.

At Bird Cage the human opponent can win if he plays cleverly. Underneath the board is a network of resistors, each corresponding to one space above. As a space is occupied, its particular resistor is short circuited. Thus electric potential between the opposite edges of the board piles up at some unshorted resistor. Each unoccupied space has a lamp. When it comes the machine's turn to play, the lamp at the point of the greatest voltage density illuminates, designating the corresponding space as the machine's next move. In play, this strategy proves to be expert though not invincible.

Shannon's most scholarly creation is a chess-playing machine. Actually this is not a special mechanism. Rather, it is a concept by which any large and fast general-purpose digital computer can be taught to play a game of chess swiftly and expertly enough to give the average player an interesting tussle. As yet no one has taken the time and trouble to construct the electronic chess player.

The latest of Shannon's machines is a mouse which solves a maze, as countless mice do in psychology laboratories throughout the world. The difference is that Shannon's mouse is a realistic, lifesize lump of gray rubber, molded around a magnet, adorned with copper whiskers, and mobilized on three wheels. As a maze-solver it is definitely in the super-mouse class.

The maze is about half the size of a desk top and has aluminum fences which can be slipped into 40 different slots in order to create problems for the mouse. When Shannon places the mouse at any spot in the maze it starts scurrying for a piece of cheese (a brass contact which rings a bell) in one corner. Every time the animal runs head on into a fence, it backs away, makes a quarter turn, and scuttles off in the new direction. By this trial and error process it finally stumbles upon the cheese. Then comes the truly extraordinary performance. Shannon replaces the mouse in some part of the maze. This time it proceeds surely and swiftly toward the cheese, never so much as brushing against a fence. It has learned the maze.

If Shannon then alters the maze, the mouse resorts to further trial and error until it has mastered the fresh arrangement of fences.

Naturally, this ability to learn a complicated pattern and to relearn its lesson when the pattern changes can not yet be crammed into so tiny a machine as the mouse's body. The brain, indeed, is in a separate case. Stripped of its fetching animism, this is the way the mouse works:

When it is set on the metal floor of the maze, its magnet trips a switch under the floor. A motor-driven electromagnet hurries to a spot directly beneath the mouse and seizes it in a magnetic grip. The magnet turns the mouse 90 degrees and propels it forward. If the copper whiskers make contact with a fence, closing a circuit, the magnet backs away, turns the mouse again, and tries anew to move it forward. Each successful sally is recorded in the mouse's brain, which is controlled by 50 relays. Interpretively, this brain considers the maze as a number of square sections. When the mouse moves without interference from one section to another, the brain registers in its memory the equivalent of: "turn North in section 5." By the time the mouse has visited every section, its brain has learned how to steer it clear of all blind alleys.

Important as they may be to telephone engineers, Shannon's machines may eventually prove to be even more significant in the life of the average citizen -- the man who knows little about telephones beyond how to use them. For Shannon's machines promise to be progenitors of a new breed of supergadgets, using the control principles which he is working out. From the mouse it is only a short step of engineering imagination to an automatic lawnmower which could be instructed to pick its way through an ornamental garden, clipping the grass without ever blundering across a flower bed. Another might retrieve balls for tennis-players. Still another might mix and bake a cake from a selection of factory-tested recipes.

ROSTER OF ORGANIZATIONS IN THE FIELD OF COMPUTERS AND AUTOMATION

(Edition 6, supplement, information as of March 3, 1953)

The purpose of this Roster is to report organizations (all that are known to us) making or developing computing machinery, or components, or data-handling equipment, or equipment for automatic control and materials handling. Each Roster entry when it becomes complete contains: name of the organization, its address, nature of its interest in the field, kinds of activity it engages in, main products in the field, approximate number of employees, year established, and a few comments and news items. When we do not have complete information, we put down what we have. The term "components" as used here does not include nuts, bolts, resistors, condensers, motors, tubes, mercury, etc., but does include magnetic drums, cores, tapes, and certain other components that have an intimate and significant connection with machinery covered in the Roster.

We seek to make this Roster as useful and informative as possible, and plan to keep it up to date in each issue. We shall be most grateful for any more information, or additions or corrections that any reader is able to send us.

Although we have tried to make the Roster complete and accurate, we assume no liability for any statements expressed or implied.

This edition contains only revisions, corrections, or additions as compared with (1) Edition 4, cumulative, published in the October, 1952, issue of THE COMPUTING MACHINERY FIELD, vol. 1, no. 4, and (2) Edition 5, supplement, published in the January, 1953, issue, vol. 2, no. 1.

Abbreviations

The key to the abbreviations follows:

Size
- Ls Large size, over 500 employees
- Ms Medium size, 50 to 500 employees
- Ss Small size, under 50 employees
  (No. in parentheses is approx. no. of employees)

Interests in Computers and Automation
- Dc Digital computing machinery
- Ac Analog computing machinery
- Ic Incidental interests in computing machinery
- Sc Servomechanisms
- Cc Automatic control machinery
- Mc Automatic materials handling machinery

When Established
- Se Organization established a short time ago (1942 or later)
- Me Organization established a "medium" time ago (1923 to 1941)
- Le Long established organization (1922 or earlier)
  (No. in parentheses is year of establishment)

Activities
- Ma Manufacturing activity
- Sa Selling activity
- Ra Research and development
- Ca Consulting
- Ga Government activity
- Pa Problem-solving activity
- Ba Buying activity
  (used also in combinations, as in RMSa, "research, manufacturing and selling activity")

*C This organization has very kindly furnished us with information expressly for the purposes of the Roster, and therefore our report is likely to be more complete and accurate than otherwise might be the case. (C for Checking)

*A This organization has placed an advertisement in this issue of COMPUTERS AND AUTOMATION. For more information, see their advertisement. (A for Advertisement)

ROSTER

American Automatic Typewriter Co., 614 North Carpenter St., Chicago 22, Ill.
Autotypist machines, for automatically typing selected paragraphs using an electric typewriter. Ls Le RMSa Ic

Audio Instrument Company, Inc., 133 West 14 St., New York 11, N.Y. *C
Electronic, mechanical, and optical analog computers. Precision electronic instruments. Fire-control equipment, logarithmic amplifiers. Specialized passive computer which corrects for film non-linearity in photometric work, etc. Designing narrow-band telemeter system, analog/digital and digital/analog converters, special-purpose digital computers, etc. Ss(10) Se(1949) DACSc RCSa *A

Avion Instrument Corp., Paramus, N.J. *C
Digital and analog computing machinery. Magnetic recorders, amplifiers, precision wire-wound potentiometers. Ms(175) Se(1946) RMSa DAIc

Edmund C. Berkeley and Associates, 36 West 11 St., New York 11, N.Y., and 19 Milk St., Boston 9, Mass. *C
Small one-of-a-kind computers (Simon) and robots (Squee). Others under development. Courses, publications. Publisher of "Computers and Automation". Ss(11) Se(1948) Dc RCMSa *A

Bull S.A. Compagnie des Machines, 94 Avenue Gambetta, Paris, France
Punch card machines. Development of electronic computer components. Ls(3000) Le Dc RMSa

Burroughs Adding Machine Co., 6071 Second Ave., Detroit, Mich., and 511 No. Broad St., Philadelphia, Pa. *C
Adding machines, bookkeeping machines, etc. Research division in Philadelphia has made Burroughs Laboratory computer, an electronic digital test computer. Also has completed a fast-access magnetic-core memory to be attached to Eniac; stores 100 numbers of 10 decimal digits; access time, 20 microseconds. Pulse control components, servomechanisms. This company owns Control Instrument Co., which SEE. Ls(18,000) Le(1896) DSc RMSPa

Computing Devices of Canada, Lim., 338 Queen St. (headquarters), and 475 Cambridge St. (laboratories), Ottawa, Ont., Canada *C
Digital and analog computers, automatic navigation systems, electronic laboratory test equipment, simulators, servomechanisms. Research and development in instrumentation, automatic control, business sorting, scientific sorting, systems analysis. Ms(100) Se(1948) DASc RCPMSa

Facit, Inc., 500 5th Ave., New York 36, N.Y. (agency), Stockholm, Sweden (headquarters), and elsewhere
Calculators, adding machines, typewriters, etc. (in 1390 A.D., copper mining). Ls(4000) Le(1390) Dc RMSa

Felt and Tarrant Mfg. Co., Comptometer Division, 1735 North Paulina St., Chicago 22, Ill. *C
Adding-calculating machines, key-driven, electric and non-electric. Comptometer. Ls(1700) Le(1886) Dc RMSa

Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N.Y., agent for Ferranti Electric Ltd., Moston, England, and Mount Dennis, Toronto, Canada
Complete electronic digital computers (Ferranti; also called "Manchester Universal Electronic Computer"). High-speed photoelectric tape reader, which can read up to 200 characters per second. Magnetic drum and electrostatic storage components, etc. Ls(10,000) Le(1896) Dc RMSa

General Ceramics and Steatite Corp., Keasbey, N.J. (near Perth Amboy, N.J.) *C
Magnetic cores for computer components; technical ceramics, insulators, etc. Ls(650) Le(1906) Ic RMSa *A

Intelligent Machines Research Corp., 134 So. Wayne St., Arlington, Va. *C
Devices for reading characters on paper, etc. Pattern interpretation equipment. Sensing mechanisms. Digital computer elements. Ss(6) Se(1951) Dc RCMSa *A

Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena 3, Calif.
Analog, digital, and data-handling systems. Ls(500 ; about 50 on computers) Me(1940) DAc RMCPa

Librascope, Inc., 1607 Flower St., Glendale 1, Calif.
Mechanical and electrical analog computers; primarily special-purpose. Ls(600; about 30 in computers) Me(1937) DASc RMSa

Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass. *C
Analog digital converter, "Automatic Digital Recorder of Analog Data" (ADRAD). Conversion and input devices. Ls(550) Le(1886) Ic RCa

Mathematisch Centrum, Amsterdam, Netherlands
Relay computer in use; electronic computer under construction. Dc RCPa

Monroe Calculating Machine Co., Orange, N.J. *C
Desk calculating machinery. Electronic digital computer research. Monrobots. Ls(4000) Me(1925) Dc RMSa *A

Ortho Filter Corp., 198 Albion Ave., Paterson, N.J.
Plug-in units for electronic digital computers. Ms(33) Se RMSa Ic

George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass. *C
Electronic analog computing equipment and components. Ss(5+) Se(1946) Ac RCMSa *A

Photon, Inc., 58 Charles St., Cambridge 38, Mass. *C
Machinery for composing type by photography. First photographically-composed book has been published. Ms(100) Me(1940) DIc RCMSa

Powers-Samas Accounting Machines Sales, Ltd., 814 North Michigan Ave., Chicago 11, Ill., agent for Powers Samas Accounting Machines Ltd., England.
Punch card tabulating equipment using small, medium, and standard cards. Agency transferred to Underwood Corp., which SEE. Ls(6000) Le(1916) DIc RMSa

Robotyper Corporation, Hendersonville, N.C.
Automatic typing equipment that can be associated with any electric typewriter, using a record roll pneumatically operated. Ic RMSa

Teleregister Corp., 157 Chambers St., New York 7, N.Y. *C
Digital and analog special purpose computers. Data inventory systems for special applications -- travel reservations, flight data processing, stock market quotations, etc. Magnetronic Reservisor, in use at American Airlines' reservations center. Associated with Western Union. Ms(275) Me(1928) DAc RMSa *A

Teletypesetter Corp., 7 Dey St., New York, N.Y.
Machines that set linotype at a distance. Ic RMSa

University of Illinois, Urbana, Ill.
Built electronic digital computer Ordvac for Ballistic Research Laboratory, Aberdeen. Has finished computer Illiac on same design, but with faster input-output using a photoelectric reader. Dc RCPa

Weems System of Navigation, 227 Prince George St., Annapolis, Md.
Automatic navigation systems. Me Ic RCPMSa

MANUSCRIPTS DESIRED FOR "COMPUTERS AND AUTOMATION"

We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many men who have expert knowledge of some part of it, but who are laymen in other parts of the field.

An author should seek to explain his subject, and show its context and significance. He should define unfamiliar terms or use them in a way that makes their meaning unmistakable. He should use examples, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions. An article may certainly be controversial if the subject is discussed reasonably.

Ordinarily, the length should be 1000 to 4000 words, and payment will be $10 to $50 on acceptance. A suggestion for an article should be submitted to us before too much work is done. To be considered for any particular issue, the manuscript should be in our hands by the 20th of the preceding month.

Possible subjects: Applications of Data-Processing Machinery to the Mail-Order Business; What Information Theory Is; Machine Translation; the Nature of Thinking; Automation in Oil Refining; and many more.

WATER AND COMPUTERS

by Henry M. Paynter, Jr., of Mass. Inst.
of Technology, and Neil Macdonald

A flow of water under pressure is a subject which invites the application of powerful computers. Engineers who make hydrodynamics their specialty are familiar with the physical concepts and the mathematical problems of flowing water; but many of them may not be familiar with computers for solving those problems. On the other hand, computer men know the properties of computers, but many of them may be unaware of how computers apply to water. It is the purpose of this discussion to be something of a bridge between these two subjects. As a result, many of the ideas expressed here will to some readers seem entirely obvious; and so we ask for the indulgence that is always needed by those who try to build a bridge between two countries.

A Hydro-Electric Plant

One of the cardinal problems involving water and computers is a large flow of water under pressure in order to generate electric power, in what is called a hydro-electric plant. A pictorial diagram of this situation is shown in Figure 1(a).

The ideas involved in this situation deserve explanation. The first element, the reservoir, is defined as a body of water large enough to even out the variation of water supply over the seasons. The conduit is a closed pipe operating under low pressure. Pressure can be measured either in pounds per square inch, psi, or in feet of head: zero head is one atmosphere or 15 pounds per square inch at sea level, and each increase of one foot in head is equal to .43 increase in psi. In a typical conduit, the diameter is about 10 feet, and the flow is about 10 feet per second, and so about 800 cubic feet of water per second will flow through it. The surge tank, as the picture shows, is an open vessel extending to the free air surface; it may be about 20 or 30 feet in diameter; and its purpose is to even out fluctuations over a period of minutes, and act as a point of pressure relief. The penstock is a closed pipe operating under high pressure; it is downstream from the surge tank and upstream from the turbine. There is a gate, not shown in the illustration, in front of the turbine to control admission of water. The turbine, basically a wheel whirled around by the water flowing against its vanes, is connected by a solid shaft to the generator, or dynamo, which changes the mechanical energy into electrical energy. The electrical energy in turn is delivered by the power transmission line to a community or load center. The water flows through the turbine into the draft tube, whence it leaves the system by what is called the tailrace. The static head is the difference between the level of the reservoir and the level of the tailrace, and typically may be 200 feet.

A rough and ready rule for the power generated by the system is: (the flow in cubic feet per second) times (the static head in feet) times (one tenth); the result is horsepower. Thus for 800 cu. ft. per sec. of flow and 200 feet of head, the power generated is 16,000 horsepower; and since use of electric power is about 2 horse-power per capita, this power would serve a community of about 8000 persons.

The Variables and the Problems

In the community, lights, heaters, motors, etc., are turned on and off, and so the load changes and more or less power is wanted. But the generator produces alternating current, and must be controlled to give 60 cycles per second, plus or minus

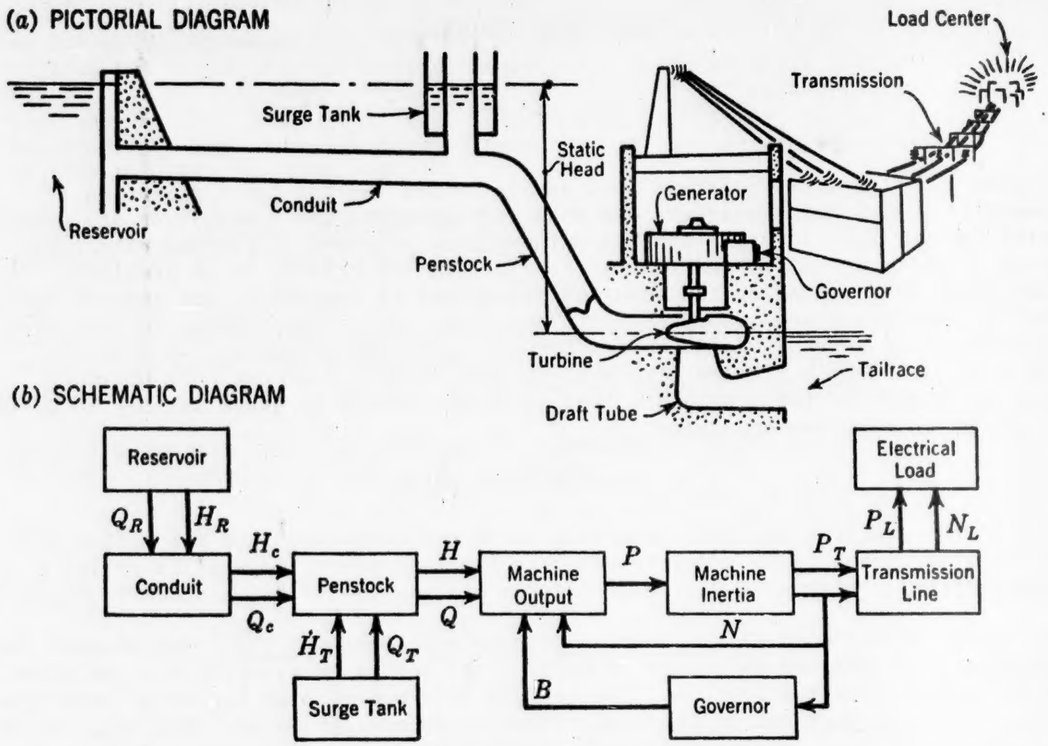

Fig. 1.—Typical Hydroelectric Installation

1/10 of a cycle. Hence, a very close control is needed. In fact, the close control has been worked out in a century of development, and consists of a very sensitive regulator, known as a flyball governor, similar to the governor which James Watt installed on his first steam engine.

The variables entering the problem are: H, head; Q, discharge or flow; B, the amount of the gate opening of the turbine; P, the power produced or delivered; and N, the speed of the generator, to be held almost constant. These variables are shown in the schematic diagram, Figure 1(b), as large letters; the small letter subscripts are the initial letters of reservoir, conduit, tank, transmission, and line, and refer to those parts of the system.

Many possible troubles can occur and do occur. Water transmits waves at the speed of sound, 2700 to 4700 feet per second, depending on the degree to which the walls of the pipe are elastic or rigid, and other factors. Sometimes, if you shut off a faucet too fast, you will hear a bang in the pipe; this is "water hammer". Water hammer is the fast pressure response, or head rise, when a flow of water is suddenly decreased.

The varying motion of the water gate in the penstock in response to the demands of the governor can set up waves in the penstock and the conduit; and although the surge tank often helps to reduce them, sometimes the only alternative to a destructive impact is wasting of water through bypassing i into the tailrace. In fact, standing or resonant waves of pressure and rarefaction can be set up in the penstock or in the conduit, and the pipe walls may burst or collapse as

a result. The governor may call for response from the gate faster than the system will allow it, for the maximum permissible rate of response depends also on the inertia of the water in the penstock. In addition, other electrical systems may be connected to this system. Although the changes of load become less disturbing to the safe running of the system because of broader distribution of load, the 60 cycle synchronism of all the systems must be maintained very close to exactly synchronous. It reminds one of the meshing of mechanical gears.

The Application of Computers

These problems are characteristically of the kind which may be solved efficiently by a general-purpose analog computer, but only awkwardly by a digital computer. Time is the independent variable; there is only one program; accuracy of three or four figures is ample.

The analog computer may be a mechanical differential analyzer, such as has been built by Mass. Inst. of Technology, General Electric, and others; or it may be an electronic analog computer, as made by G. A. Philbrick Researches, Reeves Instrument Co., and others; or a digital differential analyzer.

The physical variables are set into correspondence with elements in the computer. These elements are then associated with adders, or coefficient multipliers, or integrators, etc., analogous to the relation in the physical situation. Then the start button is pressed. In at least one machine (Philbrick) the graph of the whole solution is displayed on an oscilloscope screen within a fraction of a second after start. For any change to be investigated, one or more dials are turned and the new solution correspondingly appears. A photograph of the screen preserves the solution. In the case of other machines, the solution may be recorded by a pen on graph paper, or may be made available in other ways.

In every case, a large amount of intractable mathematical work is converted with surprising facility into the behavior of a computing machine.

WHO'S WHO IN COMPUTERS AND AUTOMATION: SECTION 2 -- BUSINESS AND NOT PROGRAMMING

(First edition, cumulative, information as of February 20, 1953)

This is the second section to be published of a Who's Who of individuals in the field of computers and automation. The purpose of this Who's Who is to make it easier for all persons interested in this field to get in touch with each other in appropriate ways.

Contents. This list consists of persons interested in computing machinery who have reported as a main interest "business" and who have not reported as a main interest "programming". Persons whose main interest is programming are included in Section 1 of the Who's Who; the first edition of Section 1 was published in the January, 1953 issue.

Reporting. If you are interested in any phase of computing machinery, robots, cybernetics, or automation, and if you would like to be included in the Who's Who, please send us: your name (please print), address, organization (and its address), your title, main interests (note list appearing under "Entry" below, and specify any other interests), year of birth, your college or last school, years of experience in the field, your occupation, and any more information about yourself that you may care to furnish. Your listing in the Who's Who does not depend in any way on your subscribing to COMPUTERS AND AUTOMATION although of course your subscription will be welcome.

Entry. Each entry in the Who's Who when it becomes complete contains: name / title, organization, address / interests / year of birth, college or last school (background), years in field, occupation. The address has been substantially contracted to avoid the nuisance of unwanted mail. In cases where no information has been given (for example, about occupation) a "-" denotes omission.

Abbreviations. Since a great deal of information is to be presented, abbreviations have been extensively used. Nearly all these abbreviations can be easily guessed, like those in a telephone book. The letters A,B,C,D,E,M,P,S stand for main interests "Applications, Business, Construction, Design, Electronics, Mathematics, Programming, Sales" respectively. Translation of some more of the abbreviations is given at the end of the list.

Liability. Although we have tried to make each entry complete and accurate, we assume no liability for any statements expressed or implied.

Corrections. We shall be very grateful for any information, additions, or corrections that any reader is able to send us.

Roster

Adams, R L / staff engr, Bendix Aviation Corp, Detroit / SAB / '15, Ga Tech, 8, admin & sales engrg
Alden, Wm L / -, Alden Sys Co, Westboro, Mass / BS / '26, Harv Bus Sch, 6, admr
Aldridge, John A / dir res, Sears Roebuck, Chi / ABCD / -, U Pa, -, mgt engr
Alexander, Samuel N / chf, Elecnc Comp Lab, N B S, Wash / ABCDE / '10, MIT, 6, elcnc scientist
Auerbach, Albert A / proj engr, Elecnc Comp Div, Underwood, NY / ABCDEM / '18, Moore Sch(ME,EE), 5, elec engr

Auerbach, Isaac L / sec hd, Burroughs Adg Mach Co, Phila / ABCDE / '21, Harv U, 6, engr
Austrian, Spencer / owner, Jean Durain of Calif, LA, Cal / B / '05, -, 0, mfr
Baldwin, Lawrence W / engr, -, Santa Monica, Cal / ABDE / '14, Cal Tech, 3, elecnc engr
Barber, Arthur W / elecnc engr, AF Camb Res Cr, Camb / ABCDE / '26, Harv, 2, elecnc engr
Barber, Wm P, Jr / secy, Conn Mut Life Ins Co, Hartford / B / '92, Trinity, Cornell, -, life ins
Bassett, Preston C / asst acty, Towers Perrin Forster & Crosby, Phila / ABM / '17, Reed Coll, 10, consltg acty
Beaver, A Richard / salesman, Addressograph-Mult Corp, NJ / ABS / '22, Amherst Coll, 3, -
Benson, Bernard S / pres, Benson-Lehner Corp, Cal / ABDES / '22, -, 10, physicist
Benton, Charles / br mgr, IBM, Buffalo / ABDEM / '13, Dartmouth, 5, -
Berkeley, Edmund C / pres, E C Berkeley & Assoc, NY / ABDM, symb log / '09, Harv, 13, consltnt
Bevan, John A / asst acty, Conn Gen Life Ins Co, Hartford / AB / '15, Yale, 9, acty
Blair, B Franklin / assoc acty, Prov Mut Life Ins Co, Phila / B / '08, Haverford, Princeton U, 0, acty
Boyd, Hugh R / exec, Instrmntn Lab, MIT, Camb / AB / '13, Wayne U, MIT, 6, engr
Bradburn, J R / vp & dir engrg, Cons Engrg Corp, Calif / BE / '11, Harv Bus Sch, 2, admn
Brail, Philip S / mgr, Chi Reg, A Kimball Co, Chi / AB / -, Nwn U, 0, sales mgr
Brustman, Joseph A / mgr, Comp Des Grp, RCA Victor, Camden / BCDE, input-output / '13, - (MS), 6, dev & des dig comp
Bucher, Harold F, Jr / sales rep, Rem Rand, Wash / ABS / '22, Pa State, 3, -
Bumstead, Ralph W / pat atty, -, Westfield, NJ / ABE / '81, Yale, -, atty
Byrnes, Wm P / prod dev engr, Teletype Corp, Chi / ABE, input-output / '26, U Minn, 3, engr
Campbell, Robert V D / asst to dir, New Prod Div, Burroughs Adg Mach Co, Phila / AB, plng / '16, Harv, 11, appld math
Carlson, Edwin Clifford / asst supvr, Tab Div, Mutual Life Ins Co, NY / ABE / '11, -, -, -
Carr, Florence K / mach instr, Travelers Ins Co., Hartford / AB, tchg / '18, IBM Sch, 17, instr
Chancellor, Justus, III / apld sci rep, IBM, Detroit / ABMS / '20, Yale, 4, math aplns
Charp, Solomon / sr staff engr, Franklin Inst Lab, Phila / ABDE / '20, U Pa, 9, engr
Chave, Edward W / admv asst, Equitable Life Ass Soc, NY / AB / '07, St. Peter's Coll, 10, acctnt
Chedaker, Joseph / res engr, Burroughs Adg Mach Co, Phila / ABCDEMS / '08, Moore Sch, 10, prod des engr
Coates, Robert P / assoc acty, Equitable Life Ass Soc, NY / AB / '11, Princeton, 0, acty
Colburn, Dorothy F / meth engr, Rem Rand, NY / ABS / '08, Simmons, Boston U, 2, -
Coleman, John S / pres, Burroughs Adg Mach Co, Detroit / ABS / -, -, -, -
Crampton, G W / res engr, Victor Adg Mach Co, Chi / ABDEM / '19, MIT, 6, elecnc comptg & measuring
Crapser, E G / vp & secy, Pacific Fire Ins Co, NY / ABE / '03, Pace, 3, acctnt
Crocker, F F / dist mgr, Calif Elec Power Co, Palm Springs, Cal / ABCDM / '00, U Colo, -, engr
Davidson, John T / chf engr, Standard Reg Co, Dayton / ABCDS / '01, Ohio State, 27, -
Dent, C H / meth res mgr, Hardware Mutuals, Wisc / AB / '99, Davis-Elkins Coll, 0, res in office meth
DeVries, Walter L / actyl supvr, Equitable Life Ass Soc, NY / ABEM / '06, U Iowa, 5, acty

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Donaldson, R D / meth res, Montgomery Ward & Co, Chi / AB / '02, Harv Engrg & Bus Sch, 15, meth res
Donovan, Robert G / sr engr, Esso Standard Oil, Linden, NJ / ABM / '23, Rensselaer Poly Inst, 2, chem engr
DuBois, W W / purch agt, Union Carbide & Carbon, NY / AB / -, -, -, -
Fenaughty, Alfred L, Jr / dev engr, Lab Adv Res, Rem Rand, NY / ABD / '26, Col U (MSEE), 6, sys dev, tab eqpt
Finger, Kenneth J / sys analyst, Ford Motor, Dearborn / ABE / '10, LaSalle U, 0, acctnt
Floyd, William B / consltg engr, -, St. Davids, Pa / ABCD / '07, Kansas State, 8, consltg engr
Gaddis, Arden H / asst res engr, -, Phila / BCDE / '21, U Ill, U Mich, 2, logl desr
Gilchrist, R C / meth & sales engr, Rem Rand, NY / ABS / '08, Colgate U, NY State Teachers Coll, 2, -
Glacken, William T / chf, Rev & Anal Br, Pine Bluff Arsenal, Ark / B / '30, Purdue, 0, statn
Greenfield, Alexander / res engr, Daystrom, NY / ABCDEM / '20, Pratt Inst, NYU, 7, res engr
Gulden, E Vincent / hd, Elecnc Res Lab, National Cash Reg, Dayton / BCDE / '15, Lafayette Coll, 11, res engr
Haagens, Daniel / des engr, Control Instr, Bklyn / BCDE / '25, Stevens, 4, engr
Hannon, Francis B / proj engr, Rem Rand, Ilion, NY / ABCD / '24, Yale, 5, engr
Harr, Luther / govt rep for Univac, Rem Rand, Wash / ABS / '20, Bowdoin, Temple, 5, sales mgr
Harris, Tom / acct rep, Rem Rand, Wash / ABS / '03, Wash U, 30, salesman
Haseltine, Robert C / assoc res engr, Burroughs Adg Mach Co, Phila / ABM / '18, U Pa, 1, mathn
Hessler, Orville G / eqpt dev, Sears Roebuck, Chi / ABCDE / '14, U Ill, 1, -
Hestenes, Arnold D / chf, Problem Formln Unit, NBS, LA, Cal / ABM / '12, Harv, -, -
Heywood, James E / tech engr, IBM, Pkpsie, NY / BDE / '25, U Cal, 3, -
Hickok, Clifton L / actyl staff asst, Mut Life Ins Co, NY / B / '10, Rutgers U, 7, -
Hoberg, George G / suprv, Elecnc Prod Dev, Burroughs Adg Mach Co, Phila / ABCDE / '24, Villanova, MIT, U Pa, 6, elecnc engr
Holberton, John Vaughan / mathn, N B S, Wash, DC / AB / '11, Temple, 7, mathn
Jewett, G G / sr acctnt, Ford Bacon & Davis, NY / AB / '98, Hamilton, 0, acctnt
Johnson, Laurence A / mgr, Tab Dept, Barco Mfg Co, Barrington, Ill / ABM / -, Nwn, 5, acctnt
Jones, Lawrence G F / consltnt, Eckert-Mauchly Div, Rem Rand, Phila / BCDEM / '20, MIT, 6, engr, physicist & mathn
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Klem, Walter / vp & assoc acty, Equitable Life Ass Soc, NY / AB / '04, -, -, -
Knecht, Harold / -, Ivan Sorvall, NY / BS / '05, Comml Coll, 25, salesman
Kraus, Max H / engrg coordr, Jerrold Elecncs Corp, Pa / ABC / '27, Cornell, 3, -
Larson, Donald O / hd, Comp Prgmg Sec, Bur Aer, Wash / ABDMS / '22, U Md, 8, mathn
Lerner, Irwin S / elec engr, Armour Res Foundn, Chi / ABCDE / '24, Okla A&M, 1, elec engrg
Levy, Jerome E / tech consltnt, -, Wash / ABDMS / '18, NYU, 8, -
Lindesmith, John L / engr, Clary Mult Corp, San Gabriel, Cal / BDE / '16, U Cal, 2, elecnc engr
Lindon, Joseph B / comml mgr, Con Edison, NY / ABDE / '93, Pace, 27, -
Macdonald, Waldron S / pres, W S Macdonald Co, Camb / ABCDES / '07, MIT, 5, -
Masterson, Earl / proj engr, Eckert-Mauchly Div, Rem Rand, Pa / BCD / '16, -, 3, -
Matthews, Russell B / asst dir, Prod Engrg Dept, Milwaukee Gas Speclty Co, Wis / ABD / '14, U Ill, 2, elec engr
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Meacham, Alan D / meth engr, Rem Rand, NY / ABS / '06, U Mich, 22, consltnt
Mechler, Eugene A / sr engr, Franklin Inst Labs, Phila / AD / '13, Columbia U, 7, res engr
Mederos, Thomas S, Jr / sales mgr, Applied Sci Corp of Princeton, NJ / ABS / '20, Princeton, 5, sales mgr
Mentzer, Rune V / plang techn, Conn Gen Life Ins Co, Hartford / ABE / '23, Lafayette, -, -
Miehle, William / assoc res engr, Burroughs Adg Mach Co, Phila / ABD / '15, MIT, Princeton, 3, engr
Miller, John H / vp & acty, Monarch Life Ins Co, Springfield, Mass / AB / -, -, 20, acty
Moody, John L / mgr, Res & Dev, Friden Calculating Mach Co, San Leandro, Cal / ABCDEM / '00, Cornell, 28, -
Morley, Howell B / purch agt, MIT, Camb / B / '05, MIT, 8, -
Morriss, B E, Jr / res engr, Dig Comp Lab, MIT, Camb / ABD / '28, MIT, 2, engr
Muschamp, G M / vp in chg engrg, Brown Instr Div, Minneapolis-Honeywell Regulator Co, Phila / ABS, process control / -, Drexel Inst Tech, 22, -
Nordquist, Leo / asst acty, West Coast Life Ins Co, San Francisco / AB / '12, U Iowa, 7, asst acty
Nungesser, J Lewis / asst cashier, Phila Natl Bk / AB, banking / '05, U Pa, 0, -
O'Beirne, James J / chf, Control Br, DAO, Soc Sec Admin, Baltimore / AB / '07, Rutgers (AB), Loyola (LLB), 7, -
Palmer, Gordon, Jr / dir mfg, Technitrol Engrg Co, Phila / BCD / '22, U Pa, 5, engr
Park, Everett J / mgr, Prud Ins Co Amer, Newark / AB / '14, Barringer H S, 4, bus admn
Philbrick, George A / pres, G A Philbrick Researches, Boston / ABCDEMS, controls, analogies / '13, Harv, MIT, 16, engr
Pickel, Leonard / procedures analyst, Amer Cyanamid Co, NY / B / '12, Rutgers, 0, -
Porter, Harry F / vp, Magnetic Metals Co, Camden, NJ / ABES / '94, -, 2, -
Quinn, J C, Jr / asst to pres, A Kimball Co, NY / ABS / '21, NYU Grad Sch of Bus, 3, sales mgt & acctg
Raudenbush, Donald H / elec engr, Cons Engrg Corp, Pasadena / ABCDE / '15, U Minn, 6, dig comp des
Reinfeld, Nyles V / consltg engr, Methods Engrg Council, Pgh / AB, optimal prgms / '23, U Akron, U Mich, 4, staff consltnt
Relis, Matthew J / sec hd, Control Instrm, Bklyn / ABCDE / '20, CCNY, MIT, 2, elec engr
Roe, Stanley S / -, Automobile Mfrs Assn, Detroit / AB / '13, U Detroit, -, statn
Schrimpf, Henry W / sr engr, Raytheon Mfg Co, Waltham, Mass / ABDES / '17, Wright-Chi, 6, meth engr
Schulhof, Wm R / editor, The Office Publg Co, NY / ABS / -, -, 1/2, publr
Schwinn, Edward A / -, USAF, Albuquerque / BEM / '28, Ohio Wesleyan U, Mich, USAF
Score, LeRoy J / -, -, Wash / ABCES / -, Geo Wash U, 5, 0
Sharpless, T Kite / secy & dir sales, Technitrol Engrg Co, Phila / ABS / '13, Haverford, U Pa, 9, -
Sherman, Jack / -, Texas Co, Beacon, NY / ABM / '07, Cal Inst Tech, 3, mathn
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Smith, James W / admnv asst to vp res, Burroughs Adg Mach Co, Phila / AB / '21, Okla A&M, 3, admin asst
Smith, Perry C / dir, New Prod Div, Burroughs Adg Mach Co, Phila / ABS / '04, Stevens Inst, 5, engr

Spielberg, Arnold / proj engr, RCA Victor Div, Camden / ABCDE, systems / '17, U Cinn, 2, engr
Sternhell, Arthur I / mgt res asst, Metrop Life Ins Co, NY / BM / '17, NYU, -, -
Stevens, Donald L / asst to dir, Adv Dev Div, Burroughs Adg Machine Co, Phila / ABDE / '23, Northeastern U, 5, res admr
Stovall, J R, Jr / proj engr, Eckert-Mauchly Div, Rem Rand, Phila / ABD, systems / '19, Duke U, 3, -
Taschioglou, Kemon P / staff asst, Res & Dev, AF Camb Res Cr / ABDS / '28, Harv Bus Sch, MIT, 1, USAF
Thompson, H G / -, -, Dayton / ABC, mfg, quality contl / '03, U Pgh, 15, engr
Tonik, Albert B / dir, Sys Study Dept, Eckert-Mauchly Div, Rem Rand, Phila / ABDEM / '25, U Pa, 3, -
Tribken, E Robert / proj engr, Sperry Gyroscope, NY / ABDES / Yale, Harv Bus Sch, 4, engr
Uline, David M / store proj engr, J L Hudson Co, Detroit / AB / '26, MIT, 1, -
Walsh, Robert L / statn, Chrysler, Detroit / AB / '14, U Detroit, 6, statn
Wang, A / owner, Wang Lab, Boston / ABCDES / '20, Harv, 5, -
Weller, David R / techl dir, J D Mountain Labs, White Plains, NY / ABDE / '20, MIT, 5, elecnc engr
Whitby, Oliver W / suprv, Engrg Dept, Stanford Res Inst, Cal / ABCD / '16, Harv U, 2, res engr
White, J Hunter, Jr / dist rep, Apld Sci Dept, IBM, NY / ABEMS / '24, Williams, Brown, Tulane, 2, mathn
Williams, Eloise / meth engr, Rem Rand, NY / ABS / '04, Wellesley, 2, engr
Williams, Waldo / dir operns, Aldens, Chi / AB / -, -, -, -
Zolad, Robert J / supvr, Acctg Sys & Meth, Ford Motor, Dearborn / AB / '15, U Chi, -, acctnt

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BACK COPIES

Vol. 1 no. 1 (Sept. 1951), vol. 1 no. 2 (Feb. 1952), and vol. 1 no. 3 (July 1952) were entitled the "Roster of Organizations in the Field of Automatic Computing Machinery", and contained that only. They were produced by ditto process, are now out of date and out of print, and are completely replaced by the "Roster of Organizations" published in vol. 1 no. 4.

Vol. 1 no. 4 (Oct. 1952) was the first issue bearing the title "THE COMPUTING MACHINERY FIELD". It contained a cumulative, up-to-date "Roster of Organizations" (a list of about 140), two articles, and a book list (mentioning 15 publications). Single copies of that issue are available at $1.25; or a subscription may be specified to begin with that issue.

Vol. 2 no. 1 (Jan. 1953) was the second and last issue bearing the title "THE COMPUTING MACHINERY FIELD". It contained a supplement of the "Roster of Organizations", four articles, a book list, and a section of the "Who's Who" listing persons interested in programming. Single copies of that issue are available at $1.25 or a subscription may be specified to begin with that issue.

THE CONCEPT OF AUTOMATION

by Edmund C. Berkeley

In the magazine "The Tool Engineer" for June, 1950, appears an article by Herman F. Zorn entitled "Automation in the Press Room". When I first read his title, it made me think of automobiles in a printing press room. But Mr. Zorn was talking about something else. He begins:

> "A press is the fastest production tool known to man. This high production tool can be made still more productive by automation — automatic devices such as roll, dial, bar and grip feeds; transfer motions; hoppers; in addition to practical safety devices to protect the machine and its tools."

He then goes on to discuss various automatic means for providing the machine with the materials it will work on.

This is undoubtedly a proper though possibly limited use of the word "automation". "Automation" essentially means "automatization"; and it comes from that word by the same sort of sensible contraction that people make when they say "preventive" instead of "preventative" and "oriented" instead of "orientated".

Automatization

When we start looking in the dictionary for the meaning of "automation" or "automatization", we find the usual chain of definitions, leading from one word to another.

"Automatization" is the "act or process of automatizing anything or the state of being automatized". "Automatize" is "to make an automaton of, to render automatic, or to reduce to an automatic condition." "Automatic" means "self-acting; having the power of motion or action within itself; not voluntary." An "automaton" is "a machine that is self-moving, or has its motive power within itself; or a living being acting in a mechanical or involuntary manner." The word "automaton" comes from two Greek roots, "auto" meaning "self", and "mat", which can be translated "mind", and so derivationally "automaton" means "something self-minded".

We can try to sum up this series of definitions. "Automation" is "the process or result of rendering machines self-acting or self-moving", or more briefly still, "rendering automatic".

A narrower and perhaps more useful definition of automation appears in the "New International 1952 Yearbook" published by Funk and Wagnalls about May 1952. It gives "automation" as a new word, and defines it as "automatic operation; theory or art or technique of making a device or machine or industrial process more fully automatic."

Self-Regulation

It is worth noting that the idea of "self-regulating" is not necessarily part of the idea of "automatic", "automaton", or "automation". In fact, the word "automaton" clearly has a connotation of the opposite, of unresponsiveness to the environment. You watch an automaton for a few minutes, and you say to yourself "How stupid!"

There is, however, another word that does carry the connotation of responsiveness to the environment. This word is "robot", coming from a Czech word "robota" referring to "compulsory service". Because of Karel Capek's famous play "Rossum's Universal Robots", the word "robot" also connotes the clever mechanical slave, and even suggests revolt from human masters.

Actually, in automation it is both essential and easy to make self-moving machines also self-regulating. Consequently, automation in many cases involves a large amount of self-regulation.

Examples

Let us take four examples of automation that can be found in or near almost any home: gas stove, automobile, refrigerator, washing machine.

The gas stove is certainly the oldest of these four examples, for gas has been supplied in pipes for over 130 years. The gas stove does supply gas automatically, and is an example of automation. Nowadays a pilot flame often provides the light for automatically igniting the gas when it is turned on. But otherwise there is little automatic behavior by a gas stove; and every mother bringing up children in the kitchen has to establish the gas stove as "danger".

The automobile, now about 50 years old, is another limited example of automation. Elaborate as its engineering now is, still from the point of view of automation an automobile substantially is only a frame with a motor that burns fuel and supplies energy to the wheels. As a whole the machine is incapable of any automatic behavior on its own — although many parts of an automobile, such as shock absorbers, are automatically responsive. Some human being must sit in the driver's seat and make all decisions about direction, speed, avoidance of obstacles, etc.

The automatic refrigerator, now about 25 years old, is a much better example of automation. In addition to being self-acting, it is self-regulating. It adjusts its behavior (its temperature) so that it remains at a specified degree of cold.

The modern washing machine, which is less than ten years old, is a still better example of automation. It will carry out a program of turning on water, soaking, washing, rinsing three times, and wringing dry, that lasts half an hour; and then it will turn itself off. True, this is a fixed program; and in the model that my family has, if the "hot" water is cold, the machine pays no attention and goes right on washing. But even from these four examples, we can see that the degree of automation in common apparatus is clearly increasing.

The Degree of Automation

It is possible to construct a set of questions which will roughly measure the degree of automation of some process or machine.

- Is it operated by a motor? or by natural forces, like pressure or light? or is it operated by a man or an animal?
- Does it carry with itself a supply of fuel? or is it fueled by a pipe or cable supplying energy?
- How many different operations does it perform by itself? How long can it continue these operations by itself? Is it always one sequence of operations? or do the sequences vary?

— How many different conditions in its environment can it respond to? Do its responses tend to regulate its behavior?

— What variety of materials can it handle? and in how many different ways?

With more space than available here, we could make a methodical analysis of the behavior of self-acting self-regulating machines. We could see ways in which techniques from many different fields could be combined to increase automation. For example, computing machinery techniques would throw light on programming any such machine.

John Diebold's "Automation"

This discussion of automation cannot be complete without reference to the new book "Automation" by John Diebold, which has just been published by Van Nostrand, and of which a brief notice appears in the January issue of THE COMPUTING MACHINERY FIELD.

The book is a thorough analysis of many of the present implications and applications of automation in business and industry; and it is full of interesting and thought-provoking ideas.

Here and there one can disagree with some of his statements. For example, Diebold maintains that a considerable amount of rethinking and redesigning is necessary in order to apply automation successfully. This is certainly true at the present time, and is likely to be true for a number of years to come.

But with a long time scale in mind, there is an enormous practical gain from self-regulating self-moving machines of roughly the same size, shape, and capacities as human beings. The spaces allotted for men in the artifacts of our civilization, such as subways, doors, stairs, and motor cars, are the wrong size for beings two feet high or ten feet high. So if any machine is to be a general-purpose messenger, for example, it should be about five or six feet high. It should be able to ring a bell, open a door, go up and down stairs, enter a subway train, see and avoid traffic, etc. A present-day efficient automatic messenger system may be a system of tubes operating with compressed air to send standard capsules of mail or bills or materials from one location to another. But it is highly limited. Every change of the system to fit changing requirements of the office or factory is difficult. It requires installation of hardware, and the permanent allocation of space.

It is clear that there is a great distance which we have to go in order to arrive at real automation of many of the activities of a postman, or a fisherman, or a doctor, or many other occupations of man.

AUTOMATIC COMPUTERS -- LIST

(Edition 1, cumulative, information as of March 3, 1953)

The purpose of this list is to report automatic computers in existence (all that are known to us). Each entry gives: name of computer (and interpretation of letters) / name of maker, place / purpose of computer, nature of computer, approximate size or capacity of computer, and quantity of computer in existence. Some words like "Model" and "Type" have been omitted from names of computers; usually the initial letters of the company name have been substituted.

Abbreviations: The key to the special abbreviations follows:

Purpose (p)

- Gp General purpose
- Sp Special Purpose

Nature of computer (c)

- Dc Digital computer
- Ac Analog computer
- Ec Electronic computer
- Rc Relay computer
- Mc Mechanical computer

Size (s)

- Ss Small size or low capacity
- Ms Medium size or medium capacity
- Ls Large size or large capacity

Quantity (q)

- 0q Zero (i.e., unfinished or dismantled)
- 1q One
- 2q Two
- Sq Small quantity, about 2 to 6
- Mq Medium quantity, about 7 to 30
- Lq Large quantity, over 30
- ?q Unknown quantity

Some other abbreviations have been used which can be easily guessed, like those in a telephone book.

We plan to keep this list up to date from time to time, and we shall be very grateful for any information which any reader is able to send us.

Although we have tried to make this list complete and accurate, we assume no liability for any statements expressed or implied.

ABC (Automatic Binary Computer) / Air Force Cambridge Res Cr, Cambridge / Gp EDc Ms 1q

Ace (automatic computing engine) / National Physical Lab, Teddington, England / Gp EDc Ms 1q

Anacom (Analog Computer) / Westinghouse Electric Co, Pittsburgh / Gp EAc Ls 1q

APEXC (All purpose X-ray computer) / Birkbeck College, Univ of London, London, England / Gp EDc Ms ?q

Arc (Automatic Relay Computer) / Birkbeck College, Univ of London, London, England / Gp RDc Ms 1q

Barber-Colman-Stibitz Computer / Barber-Colman Co, Rockford, Ill / Gp EDc Ss 1q

Bark (Binary Automatic Relay "K"omputer) / Swedish Board for Computing Machines, Drottninggatan 95A, Stockholm, Sweden / Gp RDc Ls 1q

Beac (Boeing Electronic Analog Computer) / Boeing Airplane Co, Seattle / Gp EAc Ms Mq

Bell Model VI / Bell Telephone Labs, Murray Hill, N.J. / Gp RDc Ms 1q

Bell Model V / Bell Telephone Labs, New York / Gp RDc Ls 2q

Binac (Binary Automatic Computer) / Eckert-Mauchly Div, Remington-Rand, Phila, Pa / Gp EDc Ss 1q

Burroughs Laboratory Computer / Burroughs Adding Machine Co, Phila, Pa / Sp EDc Ls lq
Cadac -- SEE CRC
Caldic (California Digital Computer)/ Univ of Calif, Berkeley, Calif / Gp EDc Ms lq
CEC 30-201 / Consolidated Engrg Co, Pasadena, Calif / Gp EDc Ss Sq
Circle Computer / Hogan Labs, New York & Nuclear Development Assoc, White Plains / Gp EDc Ss Sq
Computer / Computer Corp of America, New York / Gp EAc Ms ?q
Computer / Mathematisch Centrum, Amsterdam, Netherlands / Gp RDc Ls lq
Computer / Haller, Raymond, and Brown, State College, Pa / Sp EDc Ss lq
Computyper / Friden Calculating Machine Co, San Leandro, Calif / Gp MDc Ss ?q
CRC 101, 102, 102-A, 105, 107 / Computer Research Corp, Hawthorne, Calif / GSp EDAc SMLs Sq
CSIRO Mark I / Radiophysics Div, Commonwealth Sci and Indus Res Org, Sydney, Australia / Gp DRc Ms lq
Davis Computer / USAF Inst of Technology, Wright-Patterson Air Force Base, Dayton, Ohio / Sp EAc Ms lq
Differential Analyzer / General Electric Co, Schenectady / Gp MAc Ls lq
Differential Analyzer No. 1, No. 2 / MIT Electrical Eng Dept, Cambridge / Gp MAc, EAc Ls lq
Differential Analyzer / Moore School of Electrical Engineering, Univ of Pa, Phila / Gp MAc Ls lq
Edsac / Univ Mathematical Lab, Cambridge, England / Gp EDc Ls lq
Edvac (Electronic discrete variable automatic computer) / Moore School of Electrical Engineering, Univ of Pa, Phila / Gp EDc Ls lq
Elecom 100, 120, 200 / Electronic Computer Corp, New York / Gp EDc Ss Sq
Eniac (Electronic numerical integrator and calculator) / Moore School of Electrical Engineering, Univ of Pa, Phila, Pa, and Ballistics Res Lab, Aberdeen, Md / Gp EDc Ls lq
ERA 1101, 1102, 1103 / Engineering Res Assoc Div, St. Paul / Gp EDc Ls Sq
Ferranti / Ferranti Electric Co, Moston, Manchester, England / Gp EDc Ls Sq
Harvard Mark II, III, IV / Harvard Comp Lab, Cambridge, Mass / Gp RDc, EDc Ls lq
Hughes Computer / Hughes Res and Development Labs, Culver City, Calif / GSp EDc Ms ?q
Automatic Sequence Controlled Calculator, or Harvard Mark I / International Business Machines Corp, Endicott, N.Y., and Harvard Univ, Cambridge / Gp RDc Ls lq
IBM Card Programmed Calculator / International Business Machines Corp, New York, NY / Gp MEDc Ms Lq
IBM SSEC (Selective Sequence Electronic Calculator) / International Business Machines Corp, New York / Gp EDc Ls Oq (dismantled)
IBM 604 / International Business Machines Corp, New York / Gp EDc Ss Lq
IBM 701 / International Business Machines Corp, New York / Gp EDc Ls lq (Mq soon)
Illiac (Univ of Illinois Automatic Computer) / Univ of Ill, Urbana, Ill / Gp EDc Ls lq
Institute for Advanced Study Computer / Inst for Advanced Study, Princeton, N J / Gp EDc Ls lq
Jaincomp A, B, Bl / Jacobs Instrument Co, Bethesda, Md / Sp EDc Ss Sq
Los Alamos Computer / Los Alamos Laboratory, N M / Gp EDc Ls lq
Logistics Computer /Engineering Res Assoc Div, Remington-Rand, St. Paul / Sp EDc Ls lq
Maddida (Magnetic Drum Digital Differential Analyzer) / Bendix Comp Div, Los Angeles, Calif / Gp EDAc Ms Sq
Maniac — see Institute for Advanced Study Computer
Miniac / Marchant Research Inc, Oakland, Calif / Gp EDc Ss Oq
Monrobot / Monroe Calculating Machine Co, Orange, N.J. / Gp EDc Ss Sq
MSAC (Moore School Automatic Calculator) / Moore School of Electrical Engineering, Univ of Pa, Phila, Pa / Gp EDc Ls lq
Narec (Naval Research Laboratory Computer) / Naval Res Lab, Washington / Gp EDc Ls Oq

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Network Analyzer -- AC / General Electric Co, Schenectady / Gp EAc Ls lq
Network Analyzer -- AC / Westinghouse Electric Co, Pittsburgh / Gp EAc Ls lq
Network Analyzer — DC / General Electric Co, Schenectady / Gp EAc Ls lq
Network Analyzer — DC / Westinghouse Electric Co, Pittsburgh / Gp EAc Ls lq
Oarac / General Electric Co, Syracuse, N.Y. / Gp EDc Ms lq
ONR Relay Computer (Office of Naval Research) / Logistics Research Project, George Washington Univ, Washington / Gp RDc Ms lq
Ordvac / Univ of Ill, Urbana, Ill / Gp EDc Ls lq
Philbrick Computer / G A Philbrick Res, Inc, Boston / Gp EAc Ms Mq
Rand Computer / Rand Corp, Santa Monica, Calif / Gp EDc Ls lq
Raydac (Raytheon Digital Computer) / Raytheon Mfg Co, Waltham, Mass / Gp EDc Ls lq
Reac / Reeves Instrument Co, New York / Gp EAc Ls Lq
R-PAC (recorder playback autom comp) / Penn State College, State College, Pa / Sp EAc Ss lq
Seac (Standards Eastern Automatic Computer) / National Bureau of Standards, Washington / Gp EDc Ls 2q
Sec (Simple Electronic Computer) / Birkbeck College, Univ of London, London, England / Sp EDc Ss ?q
S-FAC (structure factor analog computer) / Penn State College, State College, Pa / Sp EAc Ss lq
Simon / Edmund C Berkeley and Assoc, New York / Sp RDc Ss lq
SPEC (Special Purpose Electronic Computer) or USAF-Fairchild Computer / NEPA Project, Fairchild Engine and Airplane Co, Oak Ridge, Tenn / Sp EDc Ms lq
Swac (Standards Western Automatic Computer) / National Bureau of Standards, Los Angeles, Calif / Gp EDc Ls lq
TC-1 / International Telemeter Corp, Los Angeles, Calif / Gp EDc Ls Oq
Univac / Eckert Mauchly Div, Remington Rand, Inc, Philadelphia / Gp EDc Ls Mq
UTEC (Univ of Toronto Electronic Computer) / McLellan Lab, Univ of Toronto, Toronto / Sp EDc Ss lq
Whirlwind I / Digital Computer Lab, Mass Inst of Tech, Cambridge 39, Mass / Sp EDc Ls lq
X-RAC (x-ray analog computer) / Penn State College, State College, Pa / Sp EAc Ms lq
Zuse Model IV / Konrad Zuse, Neukirchen, Germany, and Swiss Federal Inst of Tech, Zurich, Switzerland / Gp RDc Ls lq
Avidac (Argonne Version Institute's Digital Automatic Computer) / Argonne Natl Lab, Chi / Gp EDc Ls lq
Oracle (Oak Ridge Automatic Computer & Logical Engine) / Argonne Natl Lab, Chi / Gp EDc Ls Oq

THE ERA 1103 AUTOMATIC COMPUTER

by Neil Macdonald and E.C. Berkeley

In the March issue of "Scientific American" and one of the February issues of "Business Week" appeared an advertisement by Remington-Rand and Engineering Research Associates announcing a new high speed automatic computer, the ERA 1103. As a result of inquiry, the following information (expressed in the language of the computer field) has been learned about this machine. But since the first 1103 is not expected to be finished until late in 1953, it is likely that some of the information given here will be modified by the time the first machine is delivered.

The Type 1103 is a more advanced model of the ERA automatic computers known as Types 1101 and 1102. The Type 1101 was a general-purpose machine delivered in December, 1950. It is a flexible machine with a 400 kilocycle basic repetition rate, magnetic drum storage, and words of 24 binary digits. Eight days from the time when it was delivered, it was operating properly, and it has since established a fine record of operation. The Type 1102 is an automatic data-reduction computer being built mainly to handle calculations involving wind tunnel data.

The purpose of the Type 1103 is to solve mathematical, scientific, and engineering problems, including problems involving real-time, on-line data reduction. The space required for the machine is approximately 60 feet by 20 feet.

A machine word consists of 36 binary digits, with the binary point at the extreme right. Consequently fractions have to be scaled. A negative number is distinguished by having 1 in the column at the extreme left; a positive number, by having 0 in this column.

Rapid Memory -- Electrostatic Storage. The rapid memory of the Type 1103 consists of 1024 registers of electrostatic storage in cathode-ray tubes. The read-around ratio is 512. Whenever the machine is not reading or writing, regeneration goes on for 4 microseconds. The access time to a register of rapid memory is from 6 to 10 microseconds.

Intermediate Memory — Magnetic Drum. The intermediate memory of the machine consists of 16,384 registers of magnetic drum storage. This memory is addressed; in other words, the individual registers on the magnetic drum can be called for and consulted individually. The single drum will be about 17 inches in diameter and will rotate at about 30 revolutions per second; the peripheral velocity is held constant. The resulting surface speed is 1600 inches per second; the pulse density is about 80 polarized spots per inch of circumference. There are 4096 bits in one channel around the drum, and 4 groups of 36 heads around the drum.

ERA has developed a system referred to as "interlacing" of the addresses of registers around the drum. Under this system consecutive addresses are not placed consecutively on the drum, but at staggered intervals chosen so that the time for waiting for a location to be read by the magnetic heads is minimized. The speed of transfer of information from electrostatic storage to magnetic drum storage, and vice versa, is 30,000 binary digits per second.

Slow Memory — Magnetic Tape. The machine will also have magnetic tape memory. There will be four tape-handling machines, and each one will read, write, or erase magnetic tape. Blocks of information, 32 words long, are handled as the units of

information on the tape. The total memory capacity of the tapes is about 200,000 words. The speed of transfer of information from electrostatic storage into magnetic tape storage, and vice versa, is 750 words per second, or 27,000 binary digits per second.

Input-Output. The basic set of input-output equipment is: (1) a photoelectric punched paper tape reader; (2) a high-speed teletype paper-tape punch, which prints at the rate of 60 characters a second; (3) an electric typewriter; (4) magnetic tape as mentioned above under slow memory. Optional input-output equipment consists of: (1) a card reader for 90 column punch cards; (2) a card reader for 80 column punch cards; (3) an oscilloscope. The machine has in addition two special input-output registers: (1) Terminal Register A consisting of flipflops that store a total of 6 binary digits; and (2) Terminal Register B, flipflops storing 36 binary digits. These two registers are under the control of: (1) the computer; (2) any auxiliary equipment that takes in data from a real-time process; or (3) any auxiliary equipment that puts out data to an actuator or controller of a real-time process. The terminal register B can be loaded with information from real-time input at the rate of 36 binary digits every 24 microseconds and it can then transfer that information into the electrostatic storage memory in not more than 10 microseconds.

Arithmetic Unit. The orders the machine uses are two-address orders. The time for a two-address addition is 74 microseconds. A two-address multiplication requires 126 microseconds up to 406 microseconds, giving an average of 266 microseconds. The accumulator in the arithmetic unit will hold double-precision numbers — of 72 binary digits.

Programming. There are 45 types of orders in the instruction code, each of them two-address. Each order word consists of six binary digits and specifies one operation and two more items of information which ordinarily are the addresses of two registers. Since there are 63 possible usable combinations of six binary digits, there is room for expansion of the order code by 18 more orders which may, if desired, be wired into the computer. The design of the set of 45 orders has been based on many suggestions and much experience by the group that has been operating the Type 1101 for just over two years. One of the 1103 orders is a "repeat" order, which causes the next order to be carried out a specified number of times. Other orders also are powerful and lead to increased speed in problems like matrix multiplications, etc. The program for a problem may be stored in the magnetic drum memory as well as in the electrostatic storage memory.

Reliability — Checking. In general, no automatic checking is built into the machine. One exception is that in writing words on magnetic tape, each word is written twice so that it may be completely verified. Also, the machine has an automatic check on the main translator of orders. Since 45 out of 64 order codes are possible orders, there are 19 impossible orders, and if one of these is delivered to the main translator as an order, the machine so reports. Otherwise the machine relies on programmed checking for accuracy in the solution of problems. Marginal checking during preventive maintenance is also employed. In addition to the customary test of reduced voltage on the heaters of tubes the pulse rate is raised from 500 KC to 750 KC to test the machine.

Reliability — Operation. A complete 1103, except that it has only 1/6 of the electrostatic storage memory, is currently operating satisfactorily in the ERA St. Paul plant. The 1101 forerunner of the 1103 has given substantial operating experience, reported as: 168 hours a week of attempted operation for over 2 years; 87½% of good operating time; 2½% of unscheduled maintenance; and 10% scheduled maintenance.

GLOSSARY — Section 1: A, B

(First edition, March, 1953)

This is a glossary of terms used in the field of computers and automation. It is the purpose of this glossary to report the meaning of terms as used and not to legislate about them. Additions, comments, corrections, and criticisms will be appreciated.

-ac — an ending that means "automatic computer", as in Eniac, Seac, etc.

access time — in a digital computer, the time needed to obtain a piece of information from a register of the memory and transfer it into the arithmetic unit.

accumulator — the unit in a computer where numbers are totaled (accumulated); or the register in a computer where the result of arithmetical or logical operations is first produced.

address -- a label, name, or number identifying a register, or location where information is stored, in a computer.

addressed memory -- in a computer, storage of information where each individual register bears an address. In storage on magnetic tape, usually only blocks of a number of items of information have addresses, and an individual item does not have an individual address associated with it.

alphabetic coding -- a system of abbreviation used in preparing information for input into a machine, such that information may be reported not only in numbers but also in letters and words. For example, Boston, New York, Philadelphia, Washington, may in alphabetic coding be reported as BS, NY, PH, WA, etc. Some computers will not accept alphabetic coding but require all abbreviations to be numerical, in which case these places might be coded as 0, 1, 2, 3, etc.

analog -- using physical variables, such as distance or rotation or voltage, to represent and correspond with numerical variables that occur in a computation; contrasted with "digital".

analog computer -- a computer which calculates by using physical analogs of the variables. There is usually a one-to-one correspondence between each numerical variable occurring in the problem and a varying physical measurement in the computer.

arithmetic check — a check of a computation, making use of arithmetical properties of the computation; for example, checking the multiplication A x B by comparing it with B x A.

arithmetic unit -- the section of an automatic digital computer where arithmetical or logical operations are performed on information.

asynchronous computer — an automatic digital computer where the performance of any operation starts as a result of a signal that the previous operation has been completed; contrasted with "synchronous computer".

automatic carriage — a typewriting carriage which is automatically controlled by information and program so as to feed forms or continuous paper, space, skip, eject, tabulate, etc. It may produce any desired style of presentation of information on separate forms or on continuous paper.

automatic checking — in a computer, provision for automatically verifying the information held, transmitted, or manipulated by any device or unit of the machine. Automatic checking is "complete" when every process in the machine is automatically checked; otherwise it is partial. The term "extent of automatic checking" means either (1) the relative proportion of machine processes which are checked, or (2) the relative proportion of machine hardware devoted to checking.

automatic computer — a computer which automatically handles long sequences of operations with information.

automatic controller — a device which controls a process by (1) automatically receiving measurements of one or more physical variables of the process, (2) automatically performing a calculation, and (3) automatically issuing suitably varied actions, such as the relative movement of a valve, so that the process is controlled as desired; for example, a flyball governor on a steam engine; an automatic pilot.

automation — process or result of rendering machines self-acting or self-moving; rendering automatic; theory or art or technique of making a device or a machine or an industrial process more fully automatic.

average calculating operation — a common or typical calculating operation longer than an addition and shorter than a multiplication; often taken as the mean of nine additions and one multiplication.

binary digit — a digit in the binary scale of notation. This digit may be only 0 or 1. It is equivalent to an "on" condition or an "off" condition, a "yes" or a "no", etc.

binary notation — numbers written in the scale of two. The first dozen numbers zero to eleven are written 0, 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, 1011. The positions of the digits designate powers of two; thus 1001 means 1 times two cubed or eight, 0 times two squared or four, 0 times two to the first power or two, and 1 times two to the zero power or one; this is equal to one eight plus no four's plus no two's plus one one, which is nine.

binary number — a number written in the binary scale.

binary point — in a binary number, the point which marks the place between integral powers of two and fractional powers of two, analogous to the decimal point in a decimal number. Thus, 10.101 means four, one half, and one eighth.

binary to decimal conversion -- mathematical process of converting a number written in binary notation to the equivalent number written in the ordinary decimal notation.

bit -- binary digit (colloquial).

buss -- a channel along which information flows, usually one or more wires.

1. Patents. From Ray W. Boyer, Dayton, Ohio:

In addition to listing of "Books and Other Publications" I believe another valuable "must" to the advancement of the art would be the listing of groups of patent numbers pertaining to a specific phase of computing mechanisms with each issue of CMF.

Sounds like a good suggestion. Does anybody want to take charge of a department listing patents?

* * * *

2. Programming Library. From J. H. Wegstein, National Bureau of Standards, Wash. 25, D. C.:

The Computation Laboratory of the National Bureau of Standards plans to maintain a comprehensive library of notes, reports, and technical publications concerned with programming and coding for electronic digital computers. This will include course material, coding manuals for various computing machines, subroutines, and compiling routines. Especially desirable for this library are proposals, notes and reports which deal with methods for enabling high speed digital computers to generate their own sets of instructions for solving problems. Items need not be in finished form or formal enough for publication.

The collection of material is for the purpose of increasing efficiency in the use of high speed digital computers. All who are interested in this material are invited to make use of this library at the National Bureau of Standards Computation Laboratory in Washington. It is proposed to set up a similar library at the National Bureau of Standards Institute for Numerical Analysis in Los Angeles.

Acquisitions will be announced in Mathematical Tables and Other Aids to Computation beginning in the Jan. 1953 issue, in a new section entitled "Bibliography of Coding Procedure", along with short descriptive reviews. ...

Please send any programming library contributions direct to Mr. Wegstein.

* * * *

3. A Fair Price for a Magazine. From Joseph W. Poliseo, Cranford, N.J.:

I would like to say that I feel very much as one of your quoted (in the magazine) correspondents with respect to the cost and value of a subscription to "The Computing Machinery Field". However I also feel that my subscription may aid in your producing a better publication.

Articles directed to the fellow interested in small computers or portions of larger ones would be of most interest to me.

Good luck.

Thank you, Mr. Poliseo. We shall do our best to give the utmost in value and worthwhile information in this magazine.